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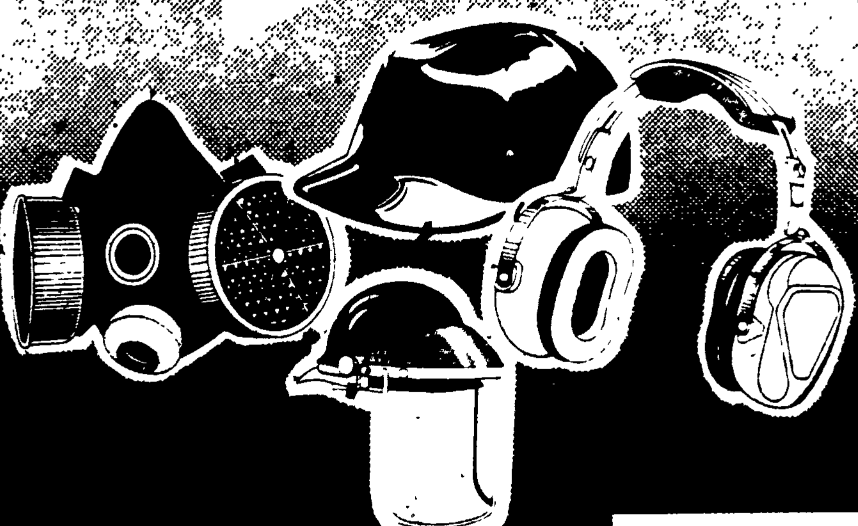
ABSTRACT

This student module on welding, cutting and brazing safety is one of 50 modules concerned with job safety and health. This module addresses safety precautions for oxyacetylene welding and gives information about handling compressed gases. Following the introduction, 17 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Describe the procedure for installing a regulator). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

SAFETY AND HEALTH

WELDING, CUTTING AND BRAZING SAFETY



MODULE SH-28

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INTRODUCTION

Welding, in any one of its 60 or more process variations, is used as a tool in many areas of construction or industry. Certain catastrophic explosions and six percent (6%) of those industrial fires that cause loss of human life can be blamed on someone's welding or cutting in an unsafe place or manner. These unsafe work practices were usually the result of the worker's being unaware of, forgetting, or ignoring the basic laws of physics and related safety requirements for the welding process.

The three elements of the fire triangle — fuel, heat, and oxygen — are present with every welding process. Many industrial fires are caused by sparks (small globules of molten metal) traveling through the air for distances of up to 40 feet. Any combustible materials in the area present a potential hazard. Electric shock, burns, and radiation hazards are also associated with arc welding. The handling of compressed gases presents potential dangers in oxyacetylene welding. Various hazardous gases, fumes, and mists may be released during many welding processes.

This module primarily addresses the safety precautions for oxyacetylene welding. Information is given about handling compressed gases and the steps involved in setting up, lighting and shutting down the oxyacetylene welding equipment. Shielded metal arc welding is covered briefly, and hazards present in several other welding processes are outlined.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Outline the five principle hazards to which welders are exposed. (Page 3)
2. Name three of the hazards inherent in the most commonly used fuel gas, acetylene. (Page 5)
3. Identify by markings and descriptions the structure, safety devices, and the basic safe handling methods of the acetylene cylinder. (Page 6)
4. Identify two main hazards associated with the use of high pressure and high purity oxygen in the general work area. (Page 10)

5. Identify by markings and descriptions the structure, safety devices, and the basic safe handling methods and controls of the high pressure oxygen cylinder. (Page 11)
6. Explain the need for a regulator on compressed gas cylinders used in welding. (Page 13)
7. Describe the procedure for installing a regulator. (Page 15)
8. Identify the characteristics of hoses acceptable for use with oxygen and fuel gas welding. (Page 18)
9. Describe the general construction characteristics of the oxyacetylene torch and the method of its attachment to the welding unit. (Page 20)
10. Cite the correct procedures for pressuring up, lighting, adjustment, and shutting down the oxyacetylene torch. (Page 22)
11. Identify the sequence of steps involved in setting up, lighting, and shutting down the oxyacetylene process. (Page 26)
12. List the personal protective clothing required for safe operation of the oxyacetylene brazing and welding process. (Page 29)
13. Identify the major hazards inherent in using the shielded metal arc welding process. (Page 31)
14. List the hazardous conditions present in the average SMAW area. (Page 33)
15. List the type of rays present in the welding arc and describe the methods of protecting the worker. (Page 34)
16. List the safety hazards common to the SMAW area. (Page 38)
17. Identify the specific hazardous conditions encountered when using various other welding processes. (Page 40)

OBJECTIVE 1: Outline the five principle hazards to which welders are exposed.

Safety in the many processes of welding, cutting, and heating metals requires certain precautions and standardized operating procedures. Welding is associated with five principal hazards: electric shock and burns, fire, compressed gas, radiant energy, and gases, fumes, and mists.

In all types of welding, the welder must exercise care to avoid burns. In electric welding, the welder must also be on guard against electric shock.

Flying sparks are the source of many industrial fires. In areas where flammable gases, vapors, and dusts are present, only a tiny spark is needed to set off a fire or explosion. Flying pieces of molten metal can fall through cracks and openings as small as nail holes and ignite combustibles that are beyond the welder's visual range. Hot metal that is being welded or cut can cause fires is allowed to contact flammable or combustible material such as drip pans, oily rags, or wooden floors. The torch flame used by the welder is another source of ignition and must be handled carefully. Oxygen, which is used in welding, if a fire hazard because it supports and intensifies the rate of combustion of other materials.

Compressed gas cylinders must be handled carefully if they are not to be a safety hazard. Gas cylinders can become lethal, unguided missiles when propelled by escaping gas.

Radiant energy hazards in welding include ultraviolet, infrared, and visible light rays. Exposure to the welding arc (ultraviolet rays) may result in very painful irritation of the eyes and skin. Infrared rays act upon the eyes simply as heat and can cause a burn or irritation of the tissue affected. The glare of excessive visible radiation can cause headaches, eye fatigue, and loss of visual efficiency. Protective eyewear must be worn during welding to prevent harm to the eyes from radiant energy.

The hazard potential of gases, fumes, and dust must be considered in welding. Gases generated by the arc include nitrous gases, deadly carbon monoxide, and ozone. Gases generated by the flame include carbon monoxide, carbon dioxide, and nitrous fumes. Metallic oxides, mineral dusts, and toxic fumes may

be given off from materials being welded, from their coatings, or from the coverings of the electrodes in arc welding. The most dangerous of these substances are cadmium, lead, zinc, beryllium, arsenic, fluorides, and cyanide.

ACTIVITY 1:*

Fill in the blanks below to supply the missing parts of the outline. (Roman numerals apply to major headings, letters to specific examples.)

FIVE HAZARDS ASSOCIATED WITH WELDING

I. Electric shock and burns.

II. ______________________________

  A. ______________________________

  B. ______________________________

  C. ______________________________

  D. Torch flame.

  E. Oxygen.

III. Compressed gas cylinders.

IV. ______________________________

  A. ______________________________

  B. ______________________________

  C. Visible radiation.

V. Gases, fumes, and dust.

  A. Gases generated by the flame.

    1. ______________________________

    2. ______________________________

    3. ______________________________

  B. Gases generated by the arc.

    1. ______________________________

    2. ______________________________

    3. ______________________________

*Answers to Activities appear on page 43.

C. Metallic oxides, mineral dusts and toxic fumes.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________

OBJECTIVE 2: Name three of the hazards inherent in the most commonly used fuel gas, acetylene.

The American Welding Society defines oxy-fuel gas welding (OFW) as any welding process that uses the heat produced by a gas flame (or flames) for melting the base metal and, if used, the filler metal that is capable of joining pieces of metal. This process is portable and is easily adapted to brazing and cutting. Students will easily recognize the typical oxyacetylene welding rig as shown in Figure 1. OFW was originally developed with acetylene as a fuel gas. Acetylene is still popular as a fuel gas because it can provide a highly localized energy that will quickly produce and sustain a molten puddle on various sizes and shapes of steel. Unfortunately for the user, acetylene is a flammable, chemically unstable gas that must be stored in special containers and handled with special precautions.

Figure 1. Typical oxyacetylene welding rig.

If acetylene is pressurized above 15 pounds per square inch gage pressure (psig), it tends to become unstable and may explosively decompose with or without external shock. Therefore, acetylene should not be used at gage pressures exceeding 15 psig.

The welding industry has improved this situation by developing methyl acetylene propadiene (MAPP), a chemically stabilized fuel gas. In addition, standard propane gas and natural gas can also be used as a fuel for cutting. Unfortunately, these alternate fuel gases do not develop the highly intense heat desirable for welding, so acetylene is still generally used for the major portion of oxy-fuel gas welding and cutting. Because of the vast difference between acetylene and other fuel gases, both in general characteristics and in the degree of hazard, acetylene should not be referred to simply as gas. Commercial acetylene even has its own distinctive odor, similar to that of garlic. Always using the name acetylene will prevent mix-ups in handling procedures.

ACTIVITY 2:

Complete the following statements from previous information.

1. Acetylene should not be used at gage pressures exceeding __________ psig.
2. Exceeding the above pressure becomes hazardous because acetylene is a chemically __________ gas.
3. Referring to acetylene by the general term __________ could result in personnel forgetting the hazards associated with acetylene.

OBJECTIVE 3: Identify by markings and descriptions the structure, safety devices, and the basic safe handling methods of the acetylene cylinder.

In order that acetylene can be transported economically and safely, a special cylinder was designed to allow the unstable acetylene to be pressurized to 250 pounds per square inch gage (psig). The steel cylinder is filled

with a porous material (Figure 2) into which a given weight of the liquid solvent acetone has been dispersed. The acetone has the ability to absorb many times its own weight of acetylene, and the mixture thus formed is then suspended in the porous material. This porous material acts as a shock absorber and thus allows safe transport of the cylinder.

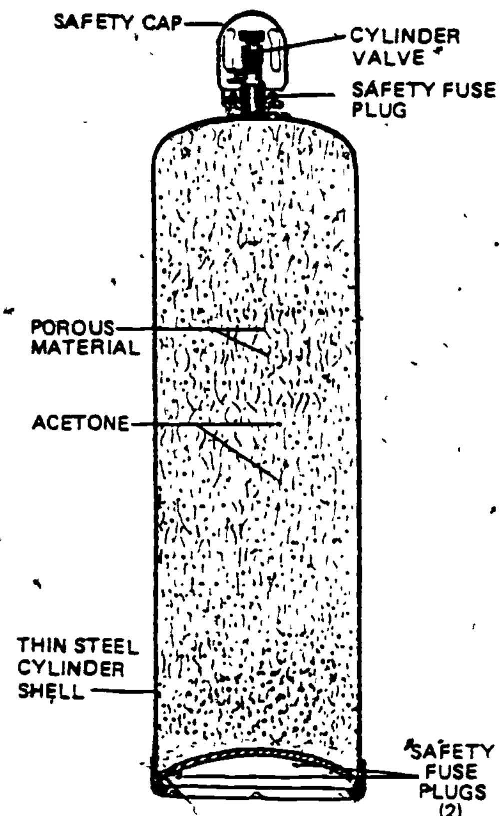


Figure 2. Acetylene cylinder.

To ensure that the wrong equipment is not attached, the acetylene cylinder valve has left-hand threads. Only fittings with grooved nuts (indicating left-hand threads) specifically designed for acetylene should be attached (Figure 3). Acetylene cylinders can be recognized as shorter, and larger in diameter than oxygen cylinders (Figure 4). The acetylene cylinder has safety relief valves located at either the top or bottom (Figure 2) of the cylinder. The fuse plug type safety valves are made from low temperature melting alloys that are designed to give way at 212°F (100°C). This action allows the gas to escape in a controlled burn rather than in an explosion, should the cylinder be involved in a fire. The other fuel gases have pop-off valves designed to function in the same manner.

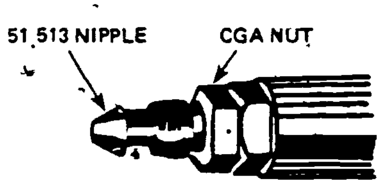


Figure 3. Standard fitting for acetylene, with grooved nut.

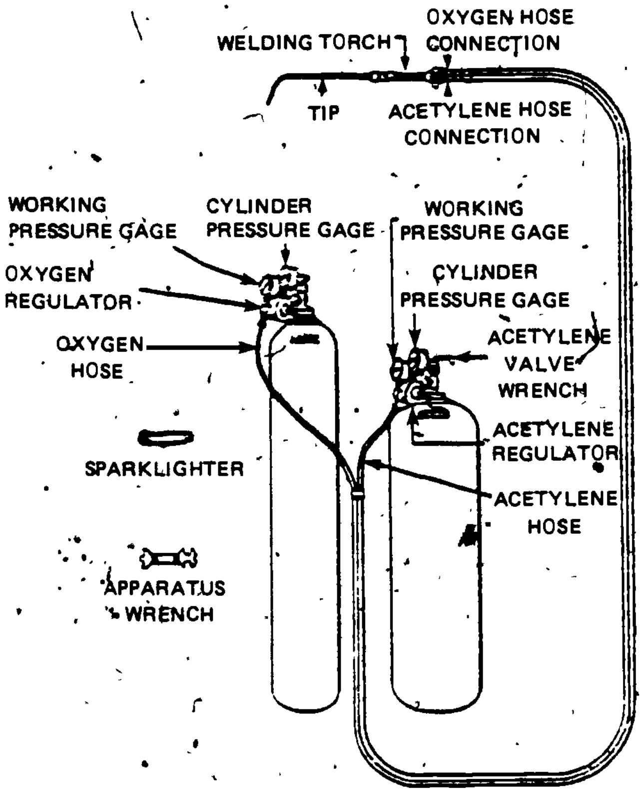


Figure 4. Oxyacetylene welding and cutting outfit.

The acetylene cylinder should always be secured in the upright position when it is being transported, stored, or used. Using the cylinder in the horizontal position will result in the liquid acetone being drawn from the cylinder along with the acetylene. Not only does this contaminate the welding equipment and the weld process, but it also results in insufficient acetone being left in the cylinder to adequately stabilize the acetylene gas. Acetylene cylinders should have the safety caps installed when they are not in use, and they should be protected from electric arcs and from dropping. They should not be used as rollers or otherwise abused in a way that may cause physical damage. A dent in the cylinder will allow large collection spots to develop inside the cylinder and thereby create a hazardous condition. Acetylene should be stored in a well-ventilated location away from flames or combustible materials. Cylinders, with safety caps installed, must be secured so that accidental tipping over will not occur.

Acetylene cylinders should only be attached to equipment manufactured for its use. Any makeshift piping that may contain more than 67% copper (such as copper tubing) can form copper acetylide, which is violently explosive with the slightest shock.

Before storage or use, the acetylene cylinder should be checked for leaks. The distinct garlic-like smell of commercial acetylene is a quick indicator that there is a leak. Checking the top stem area (Figure 5) of the cylinder valve with soapy water, or using other liquid leak checks will show if there

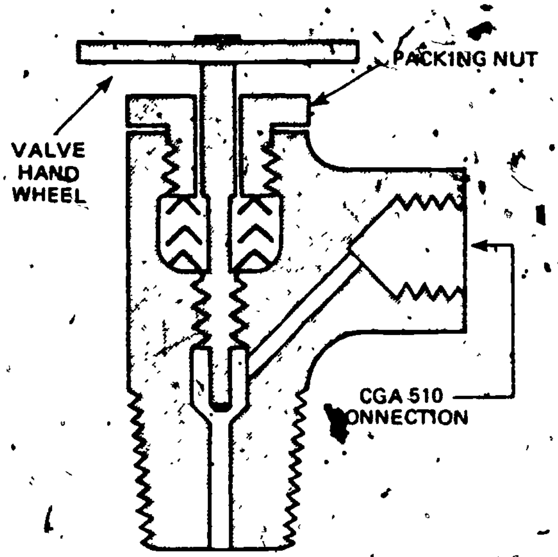


Figure 5. Acetylene cylinder valve.

is a leak. The top stem area is the most common area for leakage. The packing nut design for sealing the valve stem should be carefully tightened to stop the leak. If leakage continues, the cylinder should be moved to an open area free from flame or sparks while the vendor and safety personnel are being notified. Manufacture and maintenance of these cylinders is regulated by the Department of Transportation (DOT). Further study into the safe handling of acetylene can be found in "Safety for Compressed Gas and Air Equipment," Module SH-26, and "Safe Handling and Use of Flammable and Combustible Materials," SH-30.

ACTIVITY 3:

1. Complete the following statements to make them complete and true:

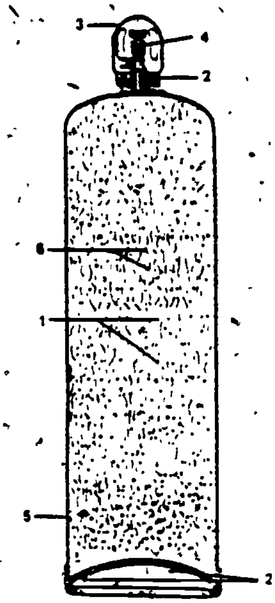
   a. Acetylene cylinders should be stored and used safely by securing them in the ______________ position.

   b. Use only ____________ and ____________ to find acetylene leaks.

   c. Do not use ____________ tubing for piping acetylene.

   d. Leaking acetylene cylinders must be __________ from the work area.

2. Identify the specific safety devices designed into the typical acetylene cylinder by matching the letter to the number in the figure at the left.



1. ____ a. Safety cap.
2. ____ b. Fuse plug.
3. ____ c. Steel cylinder shell.
4. ____ d. Acetone.
5. ____ e. Cylinder valve.
6. ____ f. Porous material.

OBJECTIVE 4: Identify two main hazards associated with the use of high pressure and high purity oxygen in the general work area.

To obtain the high temperature needed for welding (melting) steel, oxygen must be added to support the acetylene flame. Oxygen is quite different from air and should not be referred to as air. Although oxygen is colorless, odorless, tasteless, and does not burn, it does support the combustion of any flammable material. In oxyacetylene cutting processes, oxygen (of purity exceeding 99.5%) produces a chemical action (oxidation) between itself and the ferrous (iron-bearing) material. This accelerated oxidation of the steel produces added heat in the cutting area. Unfortunately, a similar chemical action (instantaneous combustion) can result if organic materials such as oil, grease, dust, or fabrics come in contact with the high purity concentration of oxygen. Instantaneous combustion is a technical way of saying explosion.

Thus, oil and grease must never come in contact with the oxygen supply or with oxyacetylene welding equipment.

Oxygen is stored under very high pressure (2,200 psig). If the valve stem should be knocked off the cylinder, the escaping oxygen can propel the cylinder at an extremely high speed (up to 30 mph within one tenth of a second). Such propulsion of the cylinder can result in serious injury or damage. To avoid this possibility, the cylinder cap should be installed to protect the valve stem whenever the cylinder is not in use.

ACTIVITY 4:

1. Name three materials that should never come in contact with high purity concentrated oxygen or with oxyacetylene equipment.
   a. ______________________
   b. ______________________
   c. ______________________
2. Although oxygen comes from the air around us, oxygen should never be referred to as air.
   True   False

OBJECTIVE 5: Identify by markings and description the structure, safety devices, and the basic safe handling methods and controls of the high pressure oxygen cylinder.

The oxygen-acetylene welding and brazing processes require an oxygen ratio of 2.5 to 1 of acetylene for maximum combustion. Oxygen, like acetylene, is stored in cylinders. However, oxygen cylinders are high pressure (2,500 psig) cylinders made of high strength forged steel with an integral safety cap and collar (Figure 6). The cylinder valve (Figure 7) has a double seating; that is, the valve seats when open as well as when closed. This prevents the high pressure oxygen from leaking around the valve stem. The valve also incorporates a safety device to guard against excessive expansion of gas

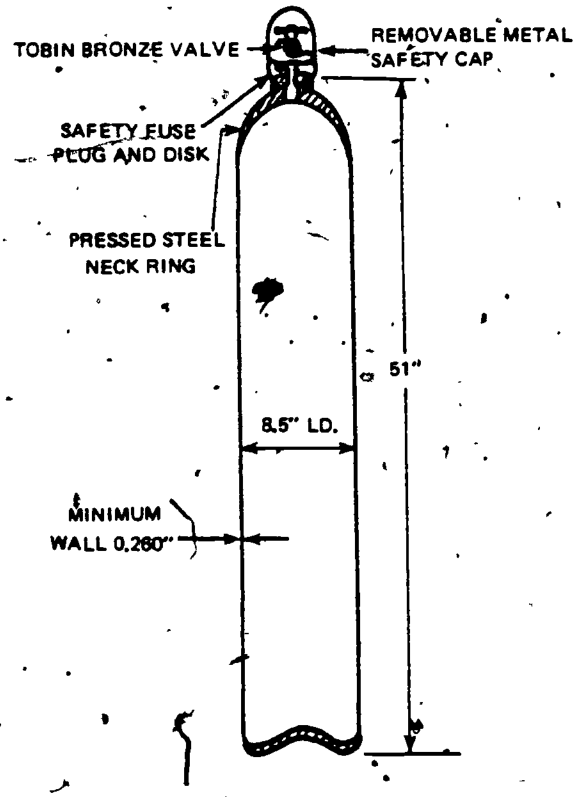


Figure 6. Oxygen cylinder.

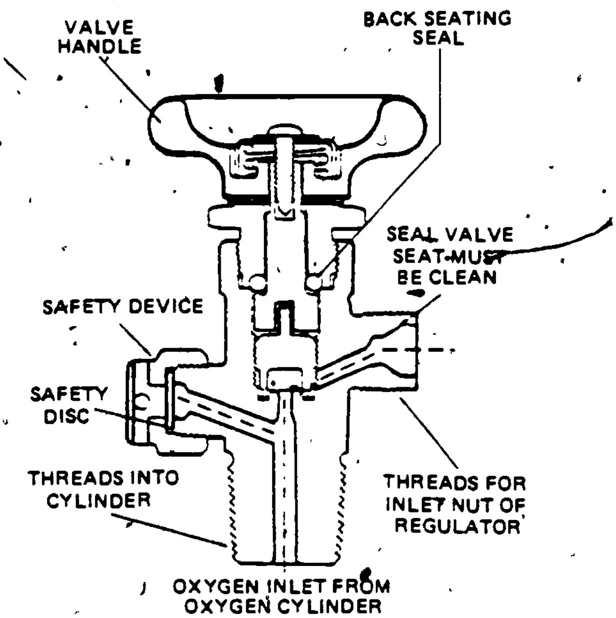


Figure 7. Oxygen cylinder valve.

pressure due to heat exposure in a fire. Rather than allowing the internal pressure to exceed the cylinder's test pressure (usually one and a half times the maximum working pressure of 2,500 lbs), the valve safety disc ruptures, and a time-controlled release of oxygen takes place. This highly compressed gas cylinder must be treated with respect, as accidental tipping over usually results in the valve being broken off. The cylinder then becomes an unguided missile propelled by the high velocity of escaping oxygen. Cylinders thus propelled have been known to penetrate cinder block walls and steel buildings with ease.

When cylinders are stored or transported, the safety cap (shown in Figure 6) must be securely in place. Workers should use specially designed cylinder carts with securing devices for all cylinder transportation.

Oxygen cylinders must be stored separately from fuel gases and must be located away from combustible materials, especially oil and grease. Care must be taken to ensure that abusive handling does not weaken the cylinder

walls. Manufacture, testing, and inspection of oxygen cylinders is controlled by the Department of Transportation (DOT). Cylinders must be hydrostatically tested (tested using liquid pressure) periodically. The date of hydrostatic testing is then stamped on the cylinder. Local distributors, who refill the cylinders, also perform hydrostatic tests at necessary intervals, according to the last date stamped.

ACTIVITY 5:

Fill in the blanks to make the following statements complete and true.

1. The oxygen cylinders can contain a maximum of ________ psig.
2. If the cylinder valve is broken off, the oxygen cylinder will accelerate like a __________.
3. The oxygen cylinder should be transported with its safety ________ securely attached.
4. Manufacture, transportation, and periodic testing of oxygen cylinders is controlled by ________ __________________________.

OBJECTIVE 6: Explain the need for a regulator on compressed gas cylinders used in welding.

The oxygen and fuel gas(es) that will be used in oxyacetylene welding are stored in cylinders at pressures too high for use directly from the cylinder. In addition, these gases must be monitored and controlled so that they can be safely mixed in the correct proportions. This function is safely accomplished by the piece of equipment shown in Figure 8, called a regulator. The oxygen regulator can indicate up to 2,500 psig of oxygen on the gage closest to the cylinder and can reduce it to a working pressure of three to seven pounds for welding, as shown by the outermost gage. The acetylene regulator must safely reduce the 250 psig in the cylinder through the dangerous pressure range. It must maintain a working pressure of one to twelve pounds while ensuring that the pressure will never exceed the fifteen psig danger point.

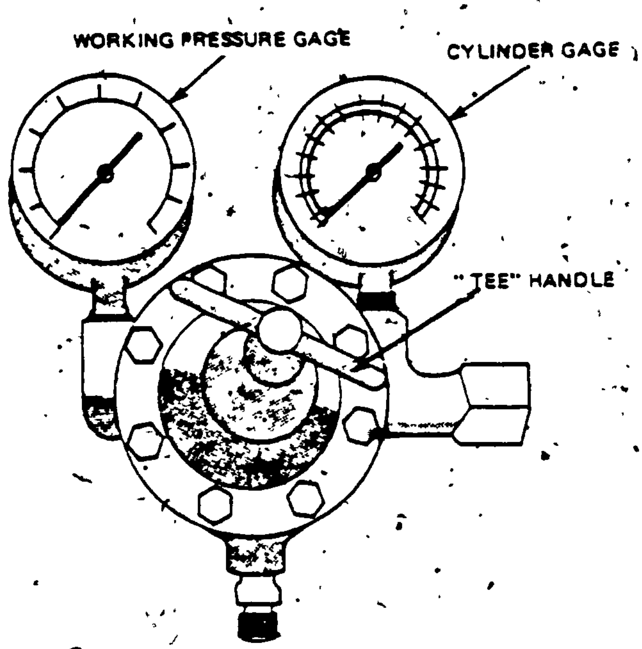


Figure 8. Gas regulator.

If a regulator steps down the cylinder pressure in one step, it is called a single-stage regulator. As the contents of the cylinders are used up, this type of regulator needs periodic readjustment of the tee-handle in order to maintain the desired working pressure. A special regulator, identified as a two-stage regulator, eliminates major adjustments because it is actually two regulators in one. The first stage reduces the cylinder pressure to an automatic, preset, constantly controlled 40 to 50 psig, depending on the brand of regulator. This intermediate pressure is then further reduced to the desired working pressure by the second stage of the regulator, when the tee-handle is screwed in (clockwise). The gas is then released through a valve that is regulated by the constant pressure against the regulator's diaphragm. This delicate mechanism, and the gages, must be protected from dirt, sudden surges of gas, or other physical damage that could cause uncontrolled leakage.

ACTIVITY 8:

Supply the word or words that will make each of the following a complete and true statement:

1. Oxygen or acetylene gas should never be used without a regulator to __________ and __________ the cylinder pressure.
2. The ______________ stage regulator will require frequent readjustment of working pressure.

3. The ______________ stage regulator actually is two regulators in one and will allow precision control of the gases used.

OBJECTIVE 7: Describe the procedure for installing a regulator.

To ensure that the welding gases are safely and accurately controlled, the worker must learn and actively participate in a systematic safety check each time the oxyacetylene welding or cutting equipment is put into use. Unfortunately, is is difficult to tell whether this equipment needs repair until the worker has actually hooked it up and tested it. The safety checks not only save damage to expensive equipment and thereby preserve human life and health, but also ensure consistency of operation. As a result, the operator can produce quality welds that, in turn, protect the life and property of the consumer.

Each regulator comes equipped with a metal filter in the inlet nipple (Figure 9) to keep foreign materials out of the regulator. Such materials could cause malfunctioning of the valves and other control assemblies. The worker is responsible for visually checking the mating surfaces on the regulator inlet fitting. This check ensures that there has been no physical damage such as nicks or dents, and that there is no obvious contaminant such as dirt, grease, or oil. Because of the hazard of oil and grease in the presence of high pressure oxygen, each oxygen regulator and gage is imprinted with the reminder: "USE NO OIL." The gage needle should indicate "0". If any other reading is shown, the gage has been subject to excessive pressures and will not give accurate readings. Malfunctioning regulators should be replaced and repaired by authorized repair persons.

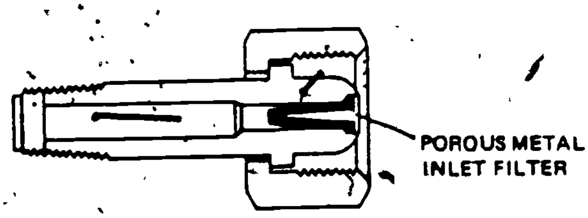


Figure 9. Porous metal inlet filter protects valve seat with high-flow filtration.

To prevent contaminants being forced into the regulator, the cylinder should be secured in the upright position, the protective cap should be removed, and the valve should be quickly opened about 1/8 turn. This procedure will expell any dirt that has collected in the cylinder valve during transit or storage (Figure 10). This operation should be done before attaching the valve and regulator, and is known as "cracking the valve." It should be done carefully while the worker is standing to one side to ensure that residue cannot be blown into the worker's face. Before "cracking" a full gas cylinder, the worker should survey the work area to be certain that no open flames or arcs are present.

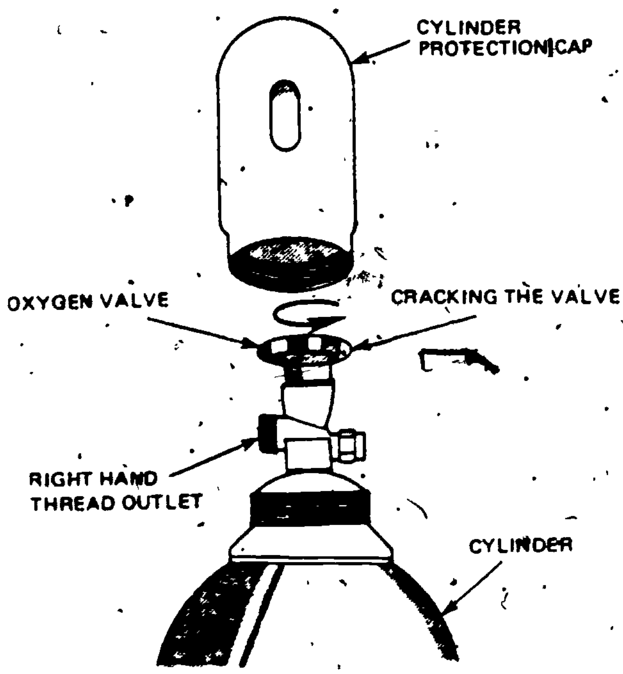


Figure 10. Cracking the valve.

The cracking operation should be followed by a careful visual examination of the cylinder valve seat area to ensure the absence of oil, grease, or physical damage, prior to any attempt to attach the regulator. (If damage is in evidence, a worker should not attempt to fix the damage by force-threading the joint.)

With the cylinder secured in the upright position, the regulator may now be safely attached. The oxygen regulator has a right hand (clockwise) female nut (Figure 11). The acetylene regulator has a male nut that has a groove cut into the fitting, indicating a left hand (counterclockwise) tightening (Figure 12). Both of the regulators should be tightened snugly with a correctly fitting wrench. The tee-handle for adjusting working pressures should be "backed out" (counterclockwise) until no resistance from the diaphragm spring (Figure 11) is felt. This closes the regulator valve assembly and does not allow gas to escape through the hose outlet if the cylinder valves are in the "on" position.

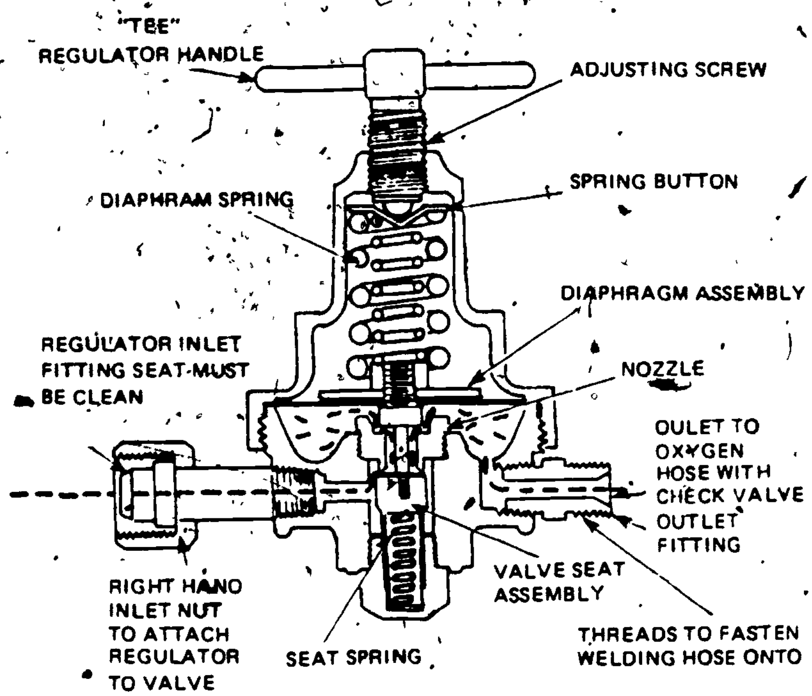


Figure 11. Oxygen cylinder regulator.

A preliminary leak check of the cylinder valve to the regulator joint can be made by slowly opening the valve, while standing to one side, until the cylinder pressure gage (the one nearest the cylinder) indicates the actual cylinder pressure, then closing the cylinder valve. Opening the cylinder valve slowly (cracking) will protect the regulator and gages from the sudden surge of high pressure gas. When opening a valve with the regulator attached, operators should observe the essential precaution of standing to one side. Then, if the regulator should fail due to the high pressure, the operator is less likely to be hit by exploding shrapnel.

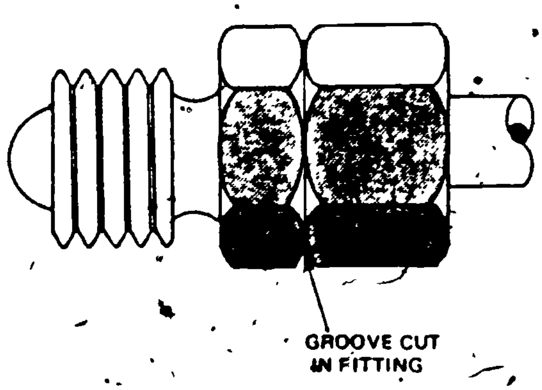


Figure 12. Standard male nut on acetylene regulator.

If the regulator gages maintain the cylinder pressure in the shut-off (tee-handle out and cylinder valve closed) condition, there are no large leaks in the connections. If the pressure indicates a constant drop, there may be a leak in either the cylinder valve to the regulator joint or in the regulator itself. Detailed leak tests using soapy water should be performed after the unit is completely assembled. If any defects in regulator operation are encountered, the complete unit

should be tagged, with the defects noted, and it should be forwarded to an authorized repair station.

ACTIVITY 7:

Choose the best answer.

1. The mating surfaces on the regulator inlet fitting should be checked for:
   a. Physical damage.
   b. Dirt.
   c. Grease or oil.
   d. All of the above.
2. "Cracking the valve" refers to:
   a. Turning the regulator valve 1/8 of a turn to clear it out (while standing to one side).
   b. Attaching the regulator to the cylinder.
   c. Turning the cylinder valve 1/8 of a turn to clear it out (while standing to one side).
   d. None of the above.
3. The acetylene regulator has a ___________ nut.
   a. Male nut with a groove cut into the fitting indicating a left-hand (counterclockwise) tightening.
   b. Female nut for right-hand (clockwise) tightening.

OBJECTIVE 8: Identify the characteristics of hoses acceptable for the use of oxygen and fuel gas welding.

One of the advantages of the oxy-fuel welding process is its high degree of portability. This characteristic is dependent on the gases being transferred to the work piece by a flexible, safe method. To transfer the gases, hoses are used. These hoses are made of fabric reinforced with rubber coating, and are usually of twin hose design to lessen hose entanglement and to maintain hose identification. The hoses are color-coded: red for acetylene and green for oxygen. The fittings are installed with a left-hand (grooved) nut on the acetylene (red) hose, and with a right-hand nut on the green oxygen

hose. Hoses that have been used for compressed air should never be used with oxy-fuel welding equipment because traces of oil from the compressor will have contaminated the hoses. To avoid contamination, compressed air should not be used to blow out any oxy-acetylene equipment.

The hoses must be long enough that the worker does not exert excess strain on the hoses, cylinders, or regulators while trying to reach the work area. If long stretches of hose are to be used, the worker needs to select the larger diameter hoses to ensure that the correct volume of gas reaches the torch. During use, the hoses may become damaged by cutting or burning. However, in NO case is taping allowed for repairs. The damaged area may be cut out, and standard metal splices used for repair, but only after a check to ensure that the insides of the hoses have not been damaged.

The hoses must be kept free of oil, gas, grease, or other materials that will degrade rubber products. Hoses should always be protected from being stepped on, run over, or tripped over. Tripping over hoses could rip connections, or knock down cylinders. Flying sparks, hot objects, and flames must also be kept away from hoses.

After the hoses have been examined for contamination, they may be attached to the regulators. The acetylene hose, which has a female thread, should be attached to the acetylene regulator, which has a male thread. The oxygen hose, which has a male thread, should be attached to the oxygen regulator.

ACTIVITY 8:

Mark each statement True or False.

______ 1. Hoses used for compressed air should never be used for oxygen or acetylene.

______ 2. A twin hose design will help eliminate entangling of hoses.

______ 3. The acetylene hose will have a left-hand fitting nut and be color coded red.

______ 4. Cuts and burns in hoses may be safely repaired by taping.

OBJECTIVE 9: Describe the general construction characteristics of the oxyacetylene torch and the method of its attachment to the welding unit.

The oxygen and the acetylene or the other fuel gases are kept separated until they reach the oxy-acetylene welding torch. The welding torch, illustrated in Figure 13, is designed to meet the safety requirements of the Underwriters' Laboratories and other safety organizations.

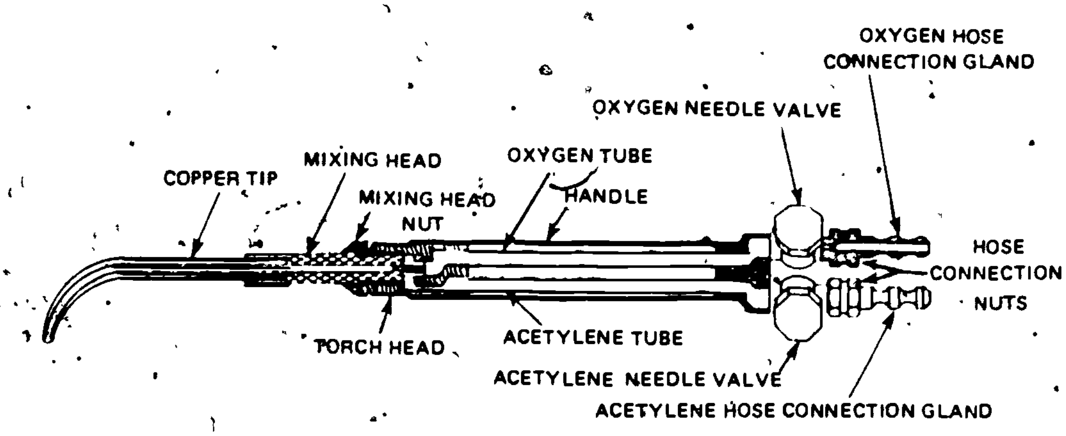


Figure 13. General purpose welding torch.

Depending on the brand name and model of the torch, the mixing of gases can take place in the torch handle, in the torch tip adaptor, or in the case of cutting tips, in the tip itself. Proper maintenance of the torch is essential for production of quality work and for safety.

The worker must practice caution even on initial assembly. Prior to hooking up the torch to the hose, the worker should purge the hose with a quick burst of oxygen to ensure that any contaminants are blown out of the hose.

The torch should be carefully examined for signs of contaminants or damage (especially to the threads) incurred during storage. Then the hose should be carefully tightened to the torch. The torch valves should then be closed and the appropriately sized welding tip installed for the final leakage testing.

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To ensure that the worker does not discover leaks through unplanned fires, the newly assembled welding unit should have each joint tested with soapy water made from soap with minimal contaminants. This test can be performed by pressurizing up the unit, then painting each joint with the soapy water (Figure 14). During each subsequent use, the unit can be easily spot-checked for leaks by the following sequence:

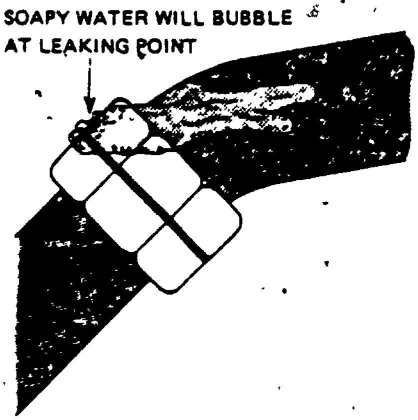

Figure 14. Leak testing.

1. With the tee handle backed out (off), turn on the cylinder valve; then close the cylinder valve. Watch the cylinder gage for signs of leakage.
2. Turn on the cylinder valves and screw the tee handle in (clockwise) to the correct operating pressure. With the torch valves closed, turn off the cylinder valve, and watch the working pressure gages for a drop in pressure.

ACTIVITY 9:

Complete the following exercises.

1. List three places the gases could be mixed in an oxy-acetylene torch:
   a. ______________________
   b. ______________________
   c. ______________________
2. Briefly describe the sequence for leak testing the welding unit:

____

____

____

OBJECTIVE 10: Cite the correct procedures for pressuring up, lighting, adjusting, and shutting down the oxyacetylene torch.

Workers must constantly monitor their techniques as well as the welding equipment. Although some malfunctions can occur during everyday use, they manifest themselves by easily detected sounds or obviously erratic operations. Workers should set up and shut down in a systematic manner, checking as they go for evidence of hazardous conditions. If the same sequence is followed during every usage of equipment, the possibility of overlooking a potential hazard will be greatly reduced.

After the torch is attached to the hoses, the cylinder valves should be slowly turned on (with the operator standing to one side). The oxygen cylinder must be opened all the way to ensure that the high pressure gas will not leak past the valve stem. The acetylene cylinder valve need be opened only 1/4 to 1 1/2 turns, and 3/4 turn is preferable. If the valve design requires a wrench to activate it, the wrench should be left on the valve throughout usage so that an emergency shutdown can be made quickly.

When the tee-handle is turned clockwise, the working pressure will increase to the setting specified by the manufacturer of the torch. The torch valve should then be opened momentarily to ensure that the correct pressure is available with the valve open. This operation also serves to purge the line. A slight drop in the gage pressure is common and may be compensated for by turning the tee-handle to increase the working pressure. Once the torch valve is closed, there will normally be a slight increase in the working pressure gage reading of one to three pounds (Figure 15).

The worker should pause and continue to observe both working pressure gages with the torch valves closed. Any additional increase in working pressure should be cause for concern. This concern is justified because a regulator that allows the working pressure to "creep" upward is an indication that there is a malfunction of the valve system (Figure 16). When "creeping" is observed, the worker should immediately back off (counterclockwise) the tee-handle, shut off the cylinder valve, and bleed the system by opening the

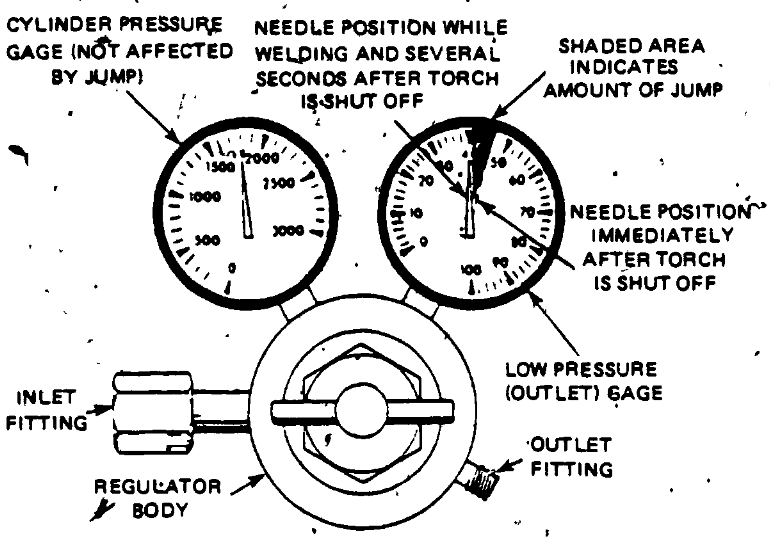

Figure 15. Needle jump.

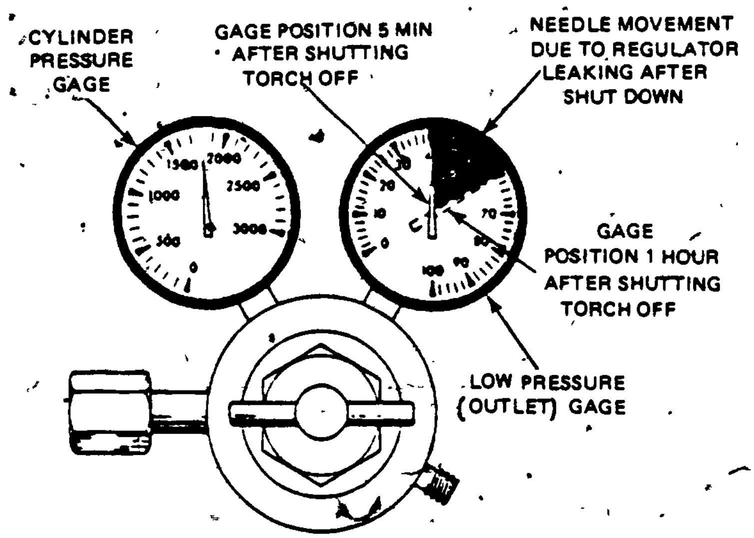

Figure 16. Creep, occurring after torch is shut off, alerts the worker to malfunction. With creep, the needle is steadily rising.

torch valve. The regulator should be immediately removed from operation, tagged with the nature of the malfunction, and forwarded to an authorized repair station.

The worker should periodically check the welding unit for correct working pressure. Just as pressure too high (over 15 psig) can be hazardous with acetylene, too low a pressure can cause the flow of acetylene through the torch to be too slow. A slow flow can be hazardous, as acetylene has a flame speed (rate of burning) of 330 feet per second. If the flow of acetylene is not sufficient, the flame can start to burn back inside the torch tip and on into the torch. This condition is known as "flashback" and usually is accompanied by a shrill hissing sound. If a flashback occurs, the flame should be

extinguished immediately by shutting off the oxygen FIRST (since oxygen is the material that supports the internal fire). The fuel gas should then be shut off. Each welding torch or regulator should be supplied with flashback or reverse-flow check valves in the torch so that flames should not be able to enter the hose. However, after a flashback has occurred, the torch assembly should be inspected by an authorized repair station before it is used again.

The worker can ensure that the correct amount (volume) of gas is supplied to each size tip by first setting the correct operating pressure on the acetylene regulator. Then the torch valve should be opened one fourth of the way, and the torch lighted with a standard torch striker. The acetylene valve should then be opened until all black soot disappears from the flame. This setting will be the optimum flow rate of acetylene for the tip selected. The oxygen can then be added to produce a neutral flame.

Another operating malfunction commonly occurring is "backfire." This is usually caused by operating the tip too close to the molten puddle, by using incorrect pressures, or by having a contaminated tip or a loose tip assembly. If repeated popping/backfire occurs, the torch should be inspected for loose joints or poor operation mechanisms.

Tips can be kept clean by systematically shutting off the fuel gas first in each normal shutdown. This will allow the oxygen to blow out any soot or contaminants in the tip. However, the technique will mask any slight leak in the acetylene valve that would keep burning if the oxygen were shut off first.

The worker is responsible not only for safe operation of the gas welding unit, but also for shutting down and securing the equipment in a safe manner. If the welding unit is not going to be used, or will be left unattended for other than a few minutes, the system should be bled. The cylinder valves of both oxygen and acetylene should be shut off first. The torch valves should then be opened to allow the trapped gas to escape. The tee-handle should then be backed out (counterclockwise) and the torch valve closed. When the equipment is shut down in this manner, the regulator gages should be on zero. The unit should then be protected from unauthorized use. When the worker wishes to use the oxyacetylene cutting process, other potential hazards arise.

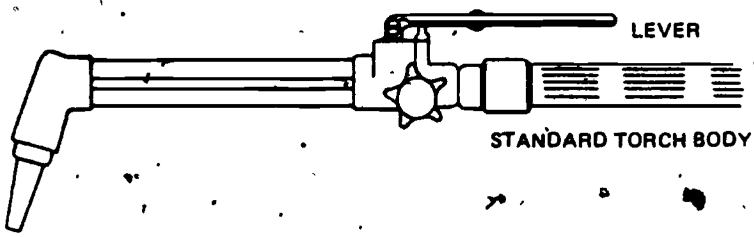

Figure 17. Cutting attachment for welding torch.

The combination torch design (Figure 17) allows the welding tips to be replaced by a cutting head. The oxygen preheat flames are now controlled by a valve at mid-torch. The cutting function of the torch is controlled by a lever valve that introduces a stream or jet of oxygen at a high pressure into the molten metal. This results in a shower of sparks exploding from the cut line. Since the shower of sparks can travel great distances (40 feet or more), the hazards of this process warrant having a person to watch for fire. The river of molten metal will burn or damage hoses, machines, and even a seemingly impervious concrete floor. If the hot molten metal is allowed to come in contact with the concrete floor, the sudden expansion of moisture in the floor will cause particles of concrete and slag to explode in all directions.

In addition, the worker must plan ahead to ensure that the material that is being cut off does not fall and injure personnel or equipment.

Cutting into or welding on containers that have contained flammable material can cause violent explosions. Each container must be treated as a potential hazard until properly cleaned. Proper cleaning may involve the use of steam, caustic solution, or flooding with inert gases such as CO_2 (carbon dioxide). The additional precaution of filling the container with water will limit the amount of volatile material present at the weld line.

After every welding or cutting operation has been completed, a fire watch should be maintained for at least one-half hour, to ensure that there are no smoldering fires.

ACTIVITY 10:

Supply the word or words to make the statement complete and true.

1. All cylinder valves should be turned on __________ to avoid damage to the regulators.
2. Oxygen cylinder valves should be completely __________ to ensure leaks will not occur around the stem.
3. Acetylene valves should be opened only __________ turns to ensure a quick emergency shutdown.
4. A regulator that allows the working pressure to keep increasing is said to be __________ and should be removed for repairs.
5. Flashback is accompanied by a __________ sound.
6. List four hazards commonly encountered when oxyacetylene cutting:
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________

OBJECTIVE 11: Identify the sequence of steps involved in setting up, lighting, and shutting down the oxyacetylene welding process.

The basic steps for setting up the oxyacetylene welding apparatus should be learned and followed routinely. To set up the welding apparatus, these steps should be carried out:

1. Inspect the valve threads.
2. Crack the cylinder valve.
3. Inspect the regulators.
4. Attach the regulators to the valves.
5. Release the tension on the adjusting screws (tee-handle).

6. Open the cylinder valves. (The preliminary leak check may be done at this point.)
7. Examine the hoses.
8. Connect the oxygen hose to the oxygen regulator.
9. Connect the fuel hose to the fuel regulator.
10. Purge the lines.
11. Inspect the torch.
12. Attach the hoses to the torch.
13. Attach the proper head, tip, or nozzle to the torch; inspect for damage, oil, or grease before connecting.
14. Check for leaks.
15. Adjust the working pressure and purge the lines.

To light the torch, wear safety goggles; use a striker instead of matches; keep acetylene at or below 15 psig; and check to see that the area is free of ignition sources. Observing these precautions, light the torch according to the following procedure:

1. Open the torch fuel gas valve about one fourth turn.
2. Light the tip.
3. Adjust the fuel gas flame.
4. Open the torch oxygen valve until a neutral flame is obtained.

To shut down the welding apparatus, follow these procedures:

1. Shut off the torch valves.
2. Close the cylinder valves.
3. Open the torch valves, and turn out the pressure-adjusting screw, then close the torch valves.
4. Uncouple the regulator.
5. Remove the regulators before moving the cylinders.
6. Maintain a fire watch for at least one half-hour after operations are completed.

ACTIVITY 11:

1. Number the following steps in proper sequence:

___ a. Examine the hoses.
___ b. Purge the lines.
___ c. Adjust the working pressure and purge the lines.
___ d. Inspect the regulators.
___ e. Check for leaks.
___ f. Attach the regulators to the valves.
___ g. Inspect the valve threads.
___ h. Inspect the torch.
___ i. Connect the oxygen hose to the oxygen regulator.
___ j. Attach the proper head, tip, or nozzle to torch; inspect for damage, oil, or grease before connecting.
___ k. Crack the cylinder valve.
___ l. Release tension on adjusting screws (tee-handle).
___ m. Connect fuel hose to fuel regulator.
___ n. Open cylinder valves.
___ o. Attach hoses to torch.

2. List, in sequence, the steps for lighting the torch.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________

3. Mark each step in the pair with a 1 or 2, according to its sequence.

___ a. Shut off the torch valves.
___ b. Close the cylinder valves.

___ c. Uncouple the regulator.
___ d. Open the torch valves; turn out the pressure-adjusting screw, and close the torch valves.

___ e. Maintain a fire watch for at least one half-hour.
___ f. Remove the regulators before moving the cylinders.

OBJECTIVE 12: List the personal protective clothing required for safe operation of the oxyacetylene brazing and welding process.

Workers using the oxy-acetylene welding or cutting process are responsible for protecting themselves and their fellow workers by keeping the immediate welding area free from flammables and by maintaining sufficient ventilation. The mere burning of the oxy-acetylene flame in a confined area can use up the oxygen needed for breathing. In addition, welding or cutting on painted or coated surfaces can produce toxic fumes. Parts that have been cleaned with chlorinated hydrocarbons, such as trichloroethane, and that have been subjected to welding heat, can produce poisonous phosgene gas.

Welding on galvanized metal will make the zinc coating volatile. In addition, use of the 6000°F flame to fuse brass at 1600°F (brazewelding) can result in overheating the 40% of zinc content of the brazing rod and the subsequent release of excessive amounts of zinc fumes. These fumes can cause zinc poisoning, with symptoms of severe fever, chills, and exhaustion.

Many nuts and bolts are now cadmium-plated to prevent rust. This cadmium coating is made volatile during welding, and like lead, can build up in the body to serious toxic levels. Use of the 6000°F flame to braze with silver alloys melting at 1300°F, or soldering with alloys melting at 400°F, usually leads to localized overheating of the joints. Some brazing and soldering materials have high percentages of cadmium in their composition. In addition, the fluxes used with these processes contain large quantities of fluorides and chlorides. Adequate fresh air and local exhaust ventilation can help to prevent exposure to toxic fumes. Additional protection can be obtained by the use of respirators complying with OSHA (Occupational Safety and Health Admintstration) regulations.

The oxy-acetylene flame also gives off low level ultraviolet rays; in addition, the heat of the flames cause the eye to be subjected to infrared heating rays. A shield or mono-goggle style (Figure 18) with filter lenses of shade number four or five should be used at all times. This mono-goggle design allows workers to wear their standard safety glasses at all times, as a secondary precaution against popping metal or flying slag. Without the

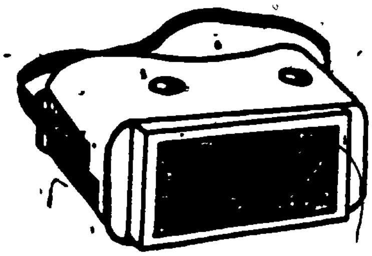

Figure 18. Mono-goggle style.

reduced glare provided by the welding and cutting goggles, the worker cannot even correctly see the neutral flame needed for production of acceptable welds. Thus, workers who fail to use welding goggles not only expose their eyes to permanent damage but also cannot produce high quality, safe welds or cuts.

All personal clothes should be as flame-retardant as possible. Most of today's synthetic materials melt readily and should be avoided. Cotton is good, but wool is better. Wearing a specially treated over-garment and high-top shoes, keeping pants cuffs turned down and pockets free of flammables such as matches, and keeping shirt-sleeves and -neck buttoned will minimize burns. If there is constant overhead welding or cutting, the worker should be dressed in special flame-retardant or leather safety equipment. Long leather gloves (gauntlets) should be used for all but the lightest of jobs (Figure 19).

Figure 19. Long leather gloves (gauntlets).

Safety shoes, a cap, and safety glasses should be a permanent part of the worker's attire. Always using a striker to ignite the torch rather than using a match or lighter will safeguard against burns to the hands.

Butane lighters have been associated with accidents fatal to welders. In one corporation, two such accidents were reported within one sixty-day period. In each case, an employee with a butane lighter in his pocket was welding. When a welding spark landed on the lighter and burned through the case, an explosion resulted. The welders were killed by the explosion in both cases.

Remember, shortcuts in welding safety are dangerous. The wearing of personal protective equipment is an essential part of the welding process.

ACTIVITY 12:

Complete the following:

1. List five personal safety items anyone working with the fuel gas welding process should wear.

   a. ______________________

   b. ______________________

   c. ______________________

   d. ______________________

   e. ______________________

2. List two fumes encountered in welding that will be detrimental to a worker's health.

   a. ______________________

   b. ______________________

OBJECTIVE 13: Identify the major hazards inherent in using the shielded metal arc welding process.

Arc welding is a process for joining metals by means of the heat created by an electric arc. The pieces to be welded are placed in position, and the intense heat of the electric arc, when applied to the joint, melts the metal. Pressure may be applied, and filler metal may be used. When the joint cools, it becomes one solid piece.

Shielded welding is a form of arc welding that uses gas and flux (a substance used to promote fusion of the metals) to blanket the welding. It is used for joining metals that oxidize readily at high temperatures (such as copper, aluminum, and stainless steel).

The American Welding Society lists eight separate welding processes under arc welding. The most common of these processes encountered by the metal worker is the shielded metal arc welding (SMAW). This process uses the heat of an electric arc (10,000°F) to melt a consumable, coated electrode and the base metal. This melting produces a mixture that solidifies to form a weld deposit (Figure 20).

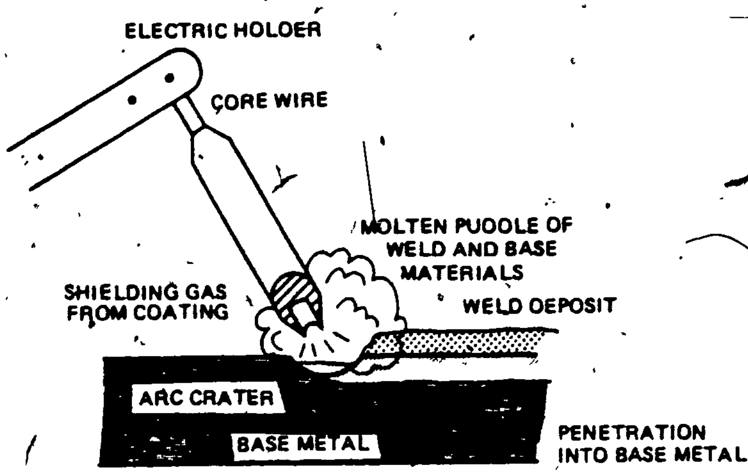

Figure 20. Shielded metal arc welding (SMAW).

To accomplish the foregoing feat, a power source capable of producing 50 to 300 amps with voltages approaching 100 volts is required. The worker must learn to control this current safely, in addition to observing and controlling a flow of molten metal through a brilliant arc.

Obviously this process (SMAW) will require special precautions to safeguard the worker. The manufacturers who produce welding power sources have accomplished their part through careful designing to standards set by the National Electrical Manufacturers Association (NEMA). This organization ensures that each welding power source is rated, contains safety devices, and is approved by the Underwriters' Laboratores prior to its sale to the welding industry.

The welding industry uses alternating current (a.c.) welding machines in which the high line voltage (outside power source) is transformed into usable welding current. Typical welding currents are 50 to 300 amps with a maximum open current voltage of 80 volts.

Each welding machine that receives its primary power from the high line should be thoroughly grounded and installed by a competent electrician. It should have a disconnect box fused within the requirements stated on the machine nameplate. The machine should always be isolated (switched off) from the power whenever it is not in use.

Prior to activating the welding machine, the worker must make sure the welding ground and the electrode holder are separated. The worker must be aware there will be between 80 and 100 volts potential between the electrode and the welding machine ground or anything the ground is attached to.

ACTIVITY 13:

Supply the correct words to make the following true statements complete.

1. The most common arc welder process used is the ____________________.

2. The workers using the SMAW may be subjected to ____________________ shock unless the welder is correctly installed.

3. The SMAW process produces a very brilliant ____________________.

4. The worker will be subjected to ____________ from molten spatters.

OBJECTIVE 14: List the hazardous conditions present in the average SMAW area.

The potential (voltage) between the work piece and the electrode (and the holder) is necessary for consistent establishment of the arc for welding. Therefore, the worker must be sure that the electrode holder is properly insulated and that the cables used for carrying the welding current are insulated by a continuous coating free from cracks or cuts. Any grounded object coming in contact with the electrode, with bare portions of the electrode holder, or with defective cables will result in a concentrated arcing. This indiscriminate arc could be disastrous if the arc occurred on highly pressurized cylinders (such as oxygen) or on containers carrying flammable materials. Th worker should also ensure that the work area is free from wet or damp areas and oily, greasy, or otherwise flammable materials. The worker should also avoid getting between the electrode, the holder, and the welder ground without the protection of long gloves (gauntlets). If the work area is wet or damp, electrical shock can result.

All bare cables should be replaced and bare machine terminals should have insulating devices installed. The worker should turn off power to the welding machine while stringing cables above traffic areas. Stringing cables

above traffic areas ensures that the cables will not be physically abused by vehicle traffic. Anytime the worker must crawl into a limited access area to perform SMAW, an assistant should be available for turning the welding machine on or off after the worker has gotten into position to weld.

ACTIVITY 14:

Mark each of the following statements True or False.

______ 1. When the welding machine is turned on, any item that is grounded will have the potential (voltage) to cause arcing.

______ 2. A wet area is a safe work area.

______ 3. Striking an arc on an oxygen cylinder can cause a violent explosion.

______ 4. Welding cables should not be run over by vehicles such as fork trucks.

OBJECTIVE 15: List the type of rays present in the welding arc and describe the methods of protecting the worker.

The most widely recognized, yet misunderstood hazard with any arc welding process is the nonionizing radiation produced by the arc itself. Few workers realize that the intensity of the ultraviolet rays and the infrared rays produced by the arc are the same as those that produce sunburn. With this arc source between fourteen inches and a few feet from eyes and unprotected skin, only a few minutes of looking at the arc will result in a "flash", or arc-burned eyes and skin. When such a burn occurs to the eyes, within a matter of hours the eyes feel as if they are filled with sand, and only medication dispensed by a physician will stop the "hurting." This condition can last from 24 to 48 hours and can lead to lost time, to accidents, and to impaired night vision.

Obviously, a person would not stand outside and look at the sun, so neither should a person look at the arc. However, many innocent bystanders do get their eyes burned or "flashed" because the arc has reflected off a

shiny surface beside other work stations, or off the shiny surface on which the welding is being performed.

For temporary welding areas, the welder should erect a flash screen to protect fellow workers. Many of the extraneous arc rays can be combated by the wearing of safety glasses with colored (shaded) side shield and lens. These "flash goggles" should be light enough that they may be worn safely in the shop area, yet dark enough to protect the workers' eyes against accidental arc flashes.

If the work area is used continuously for arc welding, the walls, ceiling, and equipment should be painted with light-absorbing colors, but the colors should not be so dark as to create a high contrast between the bright arc and the dark areas. Additional protection can be provided by establishing "see-through" protective curtains along walkways and aisles to lessen the chance of stray arc flashing.

Welders, or welders' helpers, who are in the immediate arc welding area continuously must always be on guard; maximum protection for their eyes can be supplied by welding helmets. Such protective gear (Figure 21) must be carefully maintained by the user to be sure that the correct filter glass shade is used, and that no damage has occurred to the helmet or to its components. The filter lens may be of glass or plastic but the helmet should

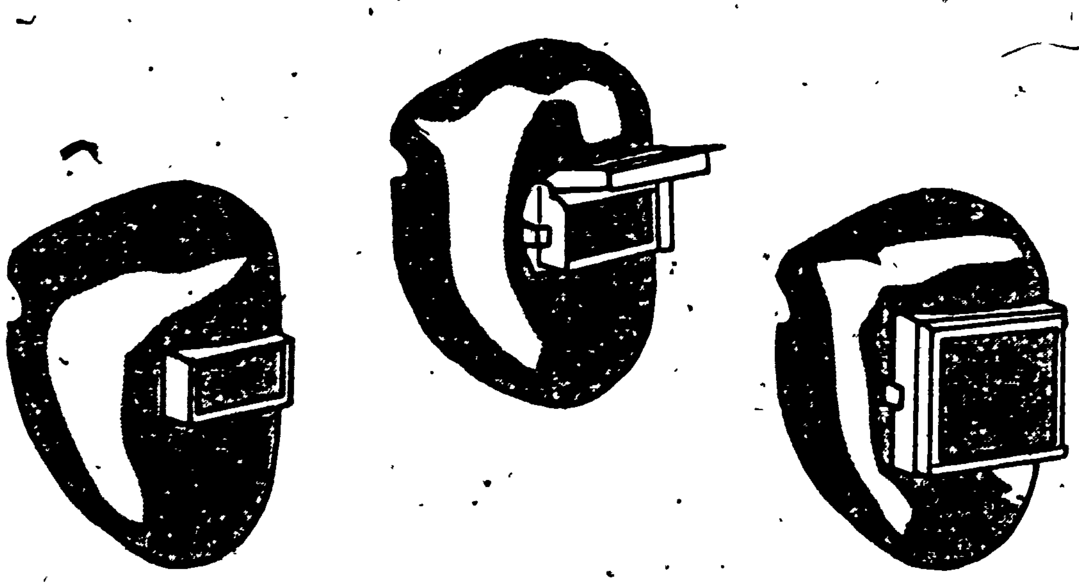

Figure 21. Welding helmets.

always have a protective, disposable, clear lens in front of and behind the filter. Any filter lens of plated design should be handled and cleaned carefully, as any scraping off of the protective coating can result in excessive ray penetration. Welding with the helmet too close to the work can cause warpage of the helmet and a leakage of arc rays will occur. The need to be closer than 14 inches may be an indication of vision problems. Work is usually done at a distance of 14 to 18 inches.

As the size of the SMAW electrode increases, so must the amperage required to melt off the electrode. With the increase in amperes comes an increase in the intensity of the arc rays. SMAW using less than 150 amps can be done safely with a filter lens shade #10; other processes or larger electrodes will require lens of #12 and #14 to be used. In no case should shades less than #10 be used. Never rely on oxyacetylene goggles for protection.

Table 1 below is a guide for the selection of the proper shade numbers of filter lenses or plates used in welding. The table is taken from the American National Standards Institute Standard Z87.1-1979 on eye and face protection.

TABLE 1. SELECTION OF SHADE NUMBER FOR WELDING FILTERS.

Welding Operation	Suggested Shade Number*
Shielded Metal-Arc Welding, up to 5/32 in (4 mm) electrodes	10
Shielded Metal-Arc Welding, 3/16 to 1/4 in (4.8 to 6.4 mm) electrodes	12
Shielded Metal-Arch Welding, over 1/4 in (6.4 mm) electrodes	14
Gas Metal-Arc Welding (Nonferrous)	11
Gas Metal-Arc Welding (Ferrous)	12
Gas Tungsten-Arc Welding	12
Atomic Hydrogen Welding	12
Carbon Arc Welding	14
Torch Soldering	2
Torch Brazing	3 or 4
Light Cutting, up to 1 in (25 mm)	3 or 4

Welding Operation	Suggested Shade Number*
Medium Cutting, 1 to 6 in (25 to 150 mm)	4 or 5
Heavy Cutting, over 6 in (150 mm)	5 or 6
Gas Welding (Light) up to 1.8 in (3.2 mm)	4 or 5
Gas Welding (Medium) 1/8 to 1/2 in (3.2 to 12.7 mm)	5 or 6
Gas Welding (Heavy) over 1/2 in (12.7 mm)	6 or 8

*The choice of a filter shade may be made on the basis of visual acuity and may therefore vary widely from one individual to another, particularly under different current densities, materials, and welding processes. However, the degree of protection from radiant energy afforded by the filter plate or lens when chosen to allow visual acuity will still remain in excess of the needs of eye filter protection. Filter plate shades as low as shade 8 have proven suitably radiation-absorbent for protection from the arc-welding processes.

Note: In gas welding or oxygen cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the operation (spectrum).

When one is welding outside in bright sunlight, the lessened contrast in light will result in less danger from arc flash; welding indoors or at night will result in greater contrast, and thus more arc burns.

The worker must protect any exposed skin by buttoning shirt collar and shirt sleeves. Work clothes should not be light in color, as they will tend to reflect the arc rays up under the helmet. Repeated burning of the skin by the ultraviolet rays has been proven to cause cancer of the skin. The wearing of contact lenses during welding is not recommended. Due to the spatter and slag involved in SMAW, wearing safety glasses behind the helmet is a good safeguard. Some authorities recommend shaded safety glasses to help guard against flash exposure. However, if the work area is somewhat dark, the worker is likely to remove shaded safety glasses to inspect the work and is then vulnerable to eye injury.

ACTIVITY 15:

Complete the following exercises:

1. List the two types of rays present in the arc.
   a. ______________________
   b. ______________________
2. List the minimum and maximum shades of filter lens used for SMAW.
   a. ______________________
   b. ______________________
3. The welder's eyes, face, and neck is protected by a ______________.
4. It is a good safety practice to wear ________ glasses under the helmet.

OBJECTIVE 16: List the safety hazards common to the SMAW area.

The concentration of several arc welders or of repetitive welding operations should warrant the establishment of a special permanent welding area that should isolate the general public from the hazards of welding. A permanent location will also allow special consideration for wall coatings that absorb the arc and for a safety plan for removal of hazards, flammables, or volatile materials from the area. Good housekeeping rules for the storage of rod stubs, permanent cable locations, fire watch, and other safeguards can be systematically established.

The SMAW process requires well designed ventilation systems to prevent several hazards. The worker may be subjected to large amounts of smoke from the arc, or to the chemical changes in the atmosphere that result as the electrode coating, the core wire, and any surface coatings are consumed (decomposed by the arc). The SMAW generates significant amounts of carbon dioxide (CO_2) and small amounts of carbon monoxide, and the worker should be aware of these two hazards. The electrode coating also contains fluxing

agents and cellular fibers. As noted on each box of SMAW electrodes, excessive amounts of smoke in confined areas can be detrimental to the worker's health. Because of this hazard, the standard welding station should be designed to pull the welding smoke down and away from the worker, not up past the worker's breathing area. (The design of welding stations should be coordinated with OSHA standards through the company safety officer, with a review of the American Conference of Governmental Industrial Hygienist design data V-S-416.0 and .1.)

The worker should be aware that welding on some materials is hazardous. Arc welding on galvanized steel, cadmium-plated parts, brasses, beryllium alloys, painted metals, and nickel or stainless steels will result in metal fumes and dangerous gases being produced. The worker should review the amount of contaminants and the length of exposure carefully, and request personal respiratory protection when needed.

If workers are doing light welding (less than 150 amps with intermittent arc times), they may wear standard long-sleeved work clothes and still obtain sufficient protection. Workers using over 150 amps and anyone performing out-of-position welding must wear protective coating such as leather bibs, sleeves or jackets that are capable of taking the molten metal spray. Long gauntlets (gloves) of leather design are mandatory, and safety shoes with deflective shields are recommended.

ACTIVITY 16:

Complete the following exercise:

1. Name four of six safety hazards found in the SMAW working environment.
   a. ______________________
   b. ______________________
   c. ______________________
   d. ______________________
2. List the protective clothing and equipment required for safe SMAW.
   a. ______________________
   b. ______________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

OBJECTIVE 17: Identify the specific hazardous conditions encountered when using various other welding processes.

As workers progress in knowledge and skill, they will encounter other arc welding processes that have specific hazards peculiar to that process.

FLUX CORE ARC WELDING

The flux core arc welding (FCAW) process has a continuous, semiautomatic feed electrode with flux on the inside of the wire. This process is capable of utilizing high currents of 200 to 300 amps on an electrode of 1/16" diameter. The arc action is accelerated and will require a filter lens of #12 or #14. In addition, smoke extractors that are attached to the welding gun are advised. The worker also must deal with wire feed and accessories that contain 110 volts a.c.

GAS TUNGSTEN ARC PROCESS (GTAW)

The gas tungsten arc process (GTAW), commonly referred to as Heliarc or TIG, uses a nonconsumable electrode of tungsten or tungsten alloy and the inert gas Argon to cover and protect the weld. Although the amperages used are lower (100 amps), the arc rays are more intense due to the lack of smoke to reduce the glare. A #11 filter should be used for steel and stainless steels. The reflective surface of aluminum and the higher amperages will need a #12 lens. The GTAW process also uses a high frequency current for arc starting, and can produce painful shock and burns. Gloves should be used at all times, and the close positions used for normal seated welding will accelerate arc burns through thin shirts. In addition, the arc reaction on the

argon and on the air in the room results in a higher concentration of ozone, a highly toxic and irritating gas.

GAS METAL ARC PROCESS

The gas metal arc process (GMAW) commonly referred to as MIG or wire welding, is similar to GTAW in that it uses a gaseous shield. However, the cover gas is usually a mixture of argon and carbon dioxide (CO_2), or it may be 100% CO_2. This gas, along with the further chemical breakdown in the arc, will necessitate a well ventilated work area.

AIR CARBON ARC GOUGING PROCESS

The air carbon arc gouging process is gaining popularity over the oxy-acetylene torch for metal removal on repair welds. This process uses an arc between a carbon electrode and the base metal to instantaneously establish a molten puddle. A jet of compressed air is then aimed at the puddle, resulting in the molten metal's being blown from the area. This process requires a filter of either #12 or #14 and will squirt molten metal from ten to twenty feet, depending on the air pressure. In addition to leather personal protective equipment, ear protection should be worn during all operations. The standard safety precautions for compressed air also apply.

To be successful in a career, the worker must not only be capable of ~~doing~~ the work of a professional, but must act like one. This involves guarding against horseplay and other unsafe conditions that might affect oneself or fellow workers.

ACTIVITY 17:

Complete the following exercises:

1. List two hazards common to FCAW.
   a. ____________________
   b. ____________________
2. List three hazards common to GTAW.
   a. ____________________
   b. ____________________
   c. ____________________

3. List two hazards common to GMAW.

a. ______________________________

b. ______________________________

4. List three hazards common to carbon arc gouging.

a. ______________________________

b. ______________________________

c. ______________________________

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ACTIVITY 1

II. Fire.

- A. Flying sparks.
- B. Flying pieces of molten metal.
- C. Hot metal.

IV. Radiant Energy.

- A. Ultraviolet rays.
- B. Infrared rays.

V.

- A. 1. Carbon monoxide.
  - 2. Carbon dioxide.
  - 3. Nitrous fumes.
- B. 1. Nitrous gases.
  - 2. Carbon monoxide.
  - 3. Ozone.
- C. 1. Cadmium
  - 2. Lead
  - 3. Zinc
  - 4. Beryllium.
  - 5. Arsenic.
  - 6. Fluorides.
  - 7. Cyanide.

ACTIVITY 2

1. Fifteen.
2. Unstable.
3. Gas.

ACTIVITY 3

1. a. Upright.
   - b. Soapy water, other liquid leak checks.
   - c. Copper.
   - d. Removed.

2. 1. D.
   2. B.
   3. A.
   4. E.
   5. C.
   6. F.

ACTIVITY 4

Any three:

1. a. Oil.
   b. Grease.
   c. Dirt.
   d. Fabrics.
2. True.

ACTIVITY 5

1. 2500.
2. Missile.
3. Cap.
4. The Department of Transportation (DOT).

ACTIVITY 6

1. Reduce; maintain
2. Single.
3. Two.

ACTIVITY 7

1. d.
2. a.
3. a.

ACTIVITY 8

1. True
2. True
3. True.
4. False.

ACTIVITY 9

1. a. Torch handle.
   b. Torch tip adapter.
   c. The tip itself.
2. Pressurize the unit and paint each joint with leak testing compound; or pressurize the system, turn off the cylinder valve and watch for drop in pressure.

ACTIVITY 10

1. Slowly.
2. Opened.
3. 1/4 to 1 1/2.
4. Creeping.
5. Hissing.
6. a. Molten slag, sparks,
   b. Burnt hoses.
   c. Popping concrete floors.
   d. Falling cutoffs.

ACTIVITY 11

1. a. 7
   b. 10
   c. 15
   d. 3
   e. 14
   f. 4
   g. 1
   h. 11
   i. 8
   j. 13
   k. 2
   l. 5
   m. 9
   n. 6
   o. 12

2. a. Open torch fuel gas valve about 1/4 turn.
   b. Light tip.
   c. Adjust fuel gas flame.
   d. Open torch oxygen valve until neutral flame is obtained.
3. a. 1
   b. 2
   c. 2
   d. 1
   e. 2
   f. 1

ACTIVITY 12

1. a. Safety shoes.
   b. A cap.
   c. Safety glasses.
   d. Leathers.
   e. Gauntlet leather gloves.
2. (Any two)
   a. Zinc poisoning.
   b. Phosgene gas.
   c. Cadmium poisoning.

ACTIVITY 13

1. Shielded metal arc welding.
2. Electric.
3. Arc.
4. Spray.

ACTIVITY 14

1. True.
2. False.
3. True.
4. True.

ACTIVITY 15

1. a. Ultraviolet.
   b. Infrared.

2. a. #14 (darker).
   b. #10 (lighter).
3. Helmet.
4. Safety.

ACTIVITY 16

(Any four)

1. a. Volatile materials.
   b. Wet surfaces.
   c. Smoke inhalation.
   d. Metal pisoning.
   e. Molten metal spray.
   f. Asphyxiation.
2. a. Long gauntlet leather gloves.
   b. Welding helmet.
   c. Leather sleeves or jacket.
   d. Safety shoes.
   e. Safety glasses.
   f. Caps or hard hats when required.
   g. Flame retardant work clothes.

ACTIVITY 17

1. a. Excessive smoke.
   b. Brighter arc.
2. a. Unfiltered arc glare.
   b. High frequency current.
   c. High concentrations of ozone.
3. a. High concentrations of CO_2.
   b. Accessories with 110 volts a.c.
4. a. Brighter arc.
   b. Compressed air.
   c. Noise.